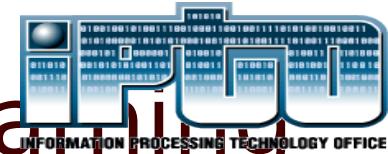




Collective Mind: Continuous, Automatic Learning to Improve Equipment Maintenance A Request for Guidance



CBM+
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Vision: New Paradigm for Maintenance Decision

Intelligent Support: Actively Manage the Maintenance Process

Cooperating at All Levels, All Phases of Operations

Continuously Improve Planning, Response, and Execution

Integrating all Elements into a Living, Distributed, Global Maintenance

Technical Approach

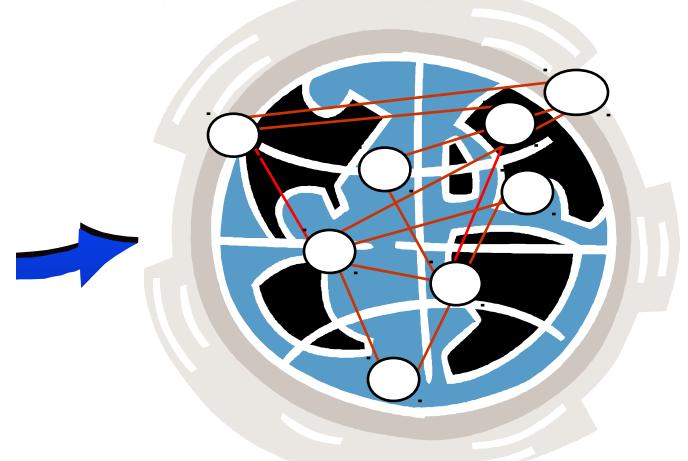
Basic Building Block:
Self-Aware Platform



Collective Mind:
Communities of
Self-Aware Platforms



Sense and Respond
Maintenance Network



Global Community of Continuously Improving Equipment

Self-Sustainment Requirement

- Army Future Force units in 2020
- Air Expeditionary Force
- Navy/Marines Sea Basing

Army: “The UA is self-sustainable for 3-7 days of operations and maintains combat power with dramatically reduced theater stockpiles.”

Critical Capabilities: Reliability Prognostics

Challenges for Prognostics

- Lack of Physics of Failure models
- Missing sensor suites
- Low equipment-utilization rates
- etc.

But Maintenance Crews

- Have the ability to improve reliability of their equipment over time

We have yet to tap the data we have!

Claim: Existing field experience can be used to improve

Prognostics

- Discover similar units
 - Peers form a “Collective”
- Evaluate unit under consideration using experience of the Collective
- Improve discovery and evaluation methods based on weapon systems success
 - Learning gives us our title “Collective Mind”

Key Technology: Statistical Machine Learning

Example: Locomotive Selection

The Mission:
Select 12 Locomotives
to go from CA to PA



Data from GE Transportation
Locomotives Network Enabled

Decision Support Data:

200+ Basic Design and Configuration Parameters
Type: Electrical System

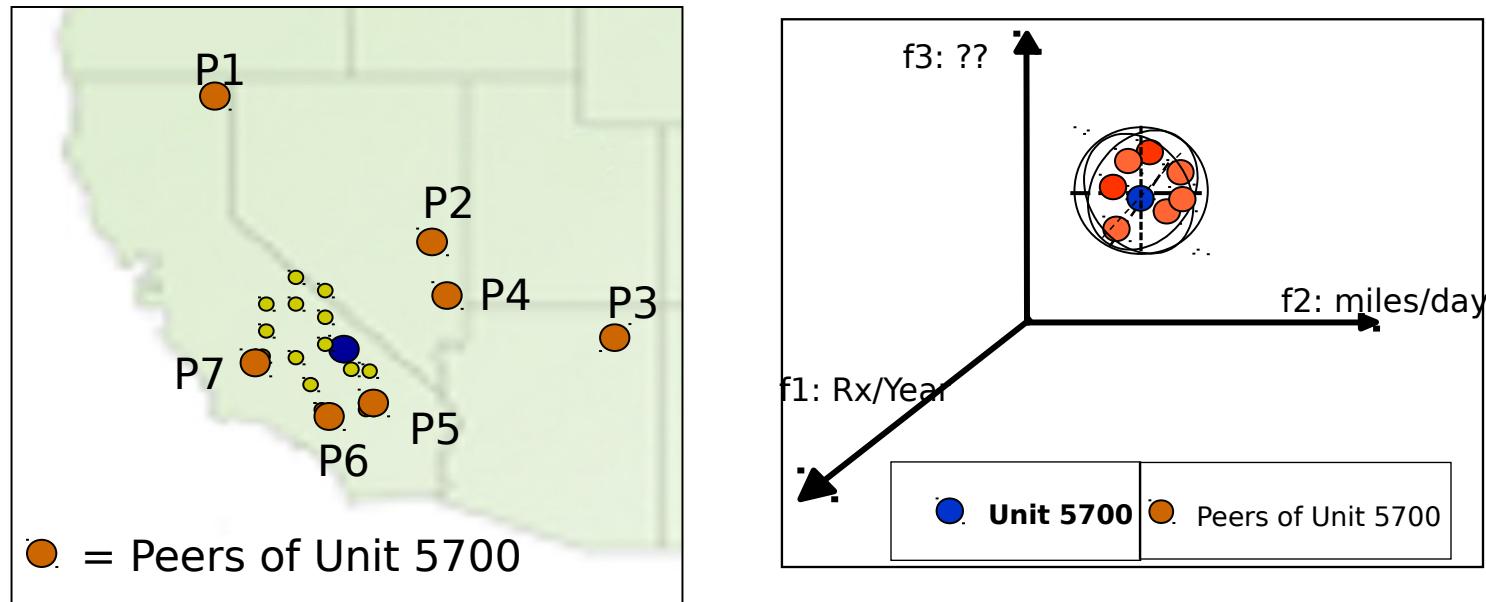
Utilization Information

Age
Mileage
Average miles/day

Maintenance Information

Time elapsed since last repair
Median time between repairs
Median time from repair to next recommendation (Rx)

Identifying Peers



Collective: Peers with similarity measure
Peer experience forms Mission Reliability
(MR) rank

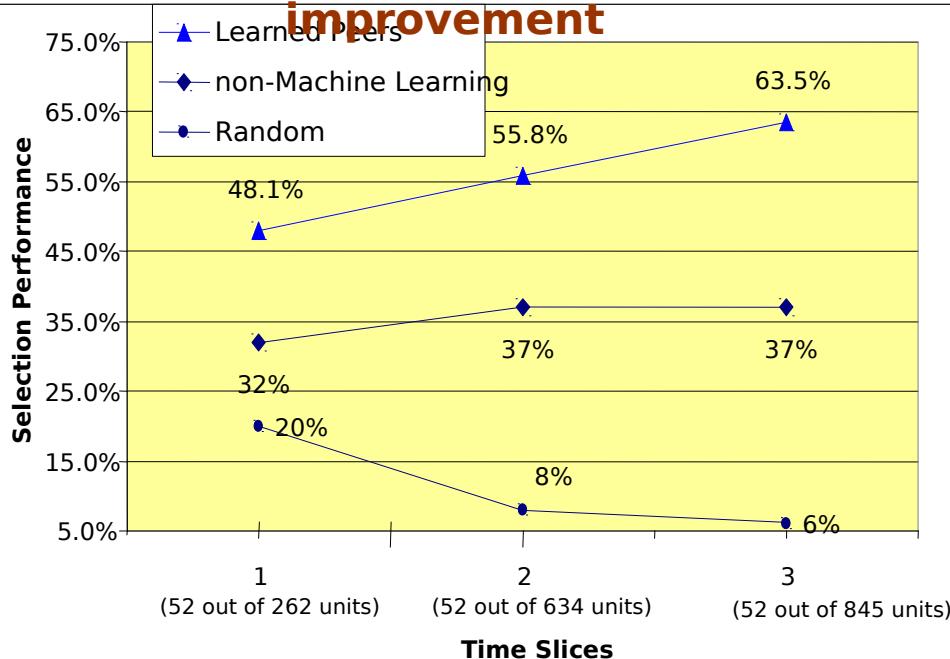
Learning: similarity measure updated by
accuracy of MR Rank

State of the Practice: non-Machine Learning

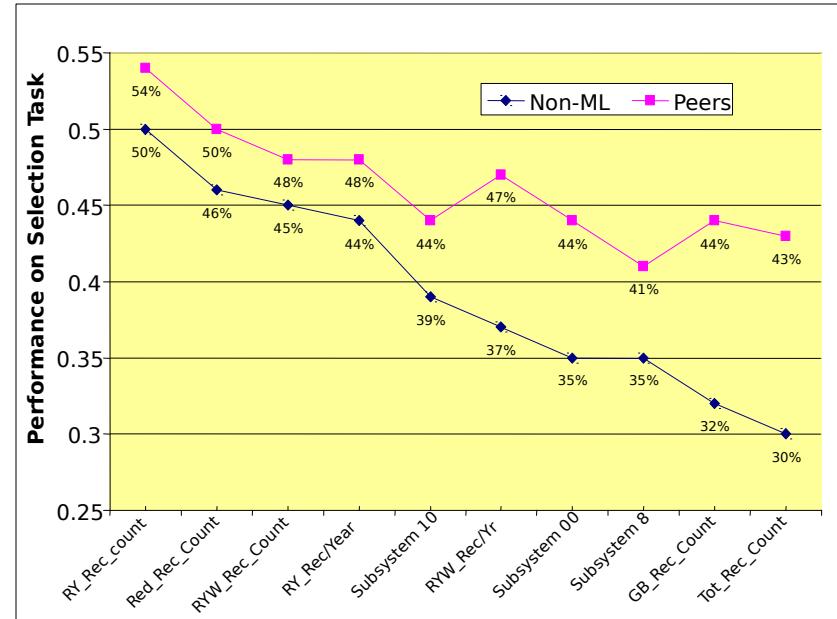
Selection Criteria	% of Correctly Classified Units: Top 20% (Sample Performance)
Lowest Mileage	17%
Newest Units	18%
Random	20%
Highest Energy (MWHRS) generated	24%
Highest Miles/ Hours Moving	26%
Highest Percentage Hours Moving	29%
Lowest Percentage of Failures in Most Critical Subsystem	38%
Lowest Ratio: Recommendations / Age	49%

Accuracy and Robustness of the Peer Approach

Learned Peers show better performance & continuous improvement



Highest contributing parameters assumed missing



Excellent Performance with Existing Sensors on Legacy Systems

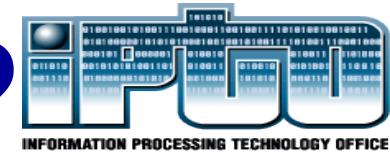
Robust to Missing Information

Guidance

- Possible Futures
 - Test in of Current Technology in Services
 - Proposals with AFRL to eLog21: F110 or F100
 - Partnership with AMCOM, Fort Rucker:
Blackhawk
 - Development of Technology
 - Meeting with ONR and Marines ALP
 - Development of Vision
 - Meeting with DARPA IXO



Questions?



Collective Mind

Continuously Improving

Equipment Maintenance

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